Are Inflation Rates Really Nonstationary? New Evidence from Non-linear STAR Framework and African Data

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Abstract

This study provides evidence on whether the inflation rate is nonstationary or stationary using quarterly inflation rate data from thirty-four African countries. As Johansen [Journal of Policy Modeling 14 (1992) 313-334] wrote, "Some time series such as the log of prices (P), have the property that even the inflation rate ΔP is nonstationary, whereas the second difference Δ2P is stationarity." Results from linear and nonlinear analyses provide overwhelming evidence in support of the nonstationarityof the inflation rate in Africa. The nonlinear KSS test validates thenonstationarity of inflation in more countries than the linear tests. Results from three forecasting tests indicate constancy of our models and the associated evidence of nonstationarity.

Keywords: Time-Series Models, Dynamic Treatment Models Price Level, Inflation

1. Introduction

In a seminal paper, Nelson and Plosser (1982), challenged the conventional view of trend-stationarity of macroeconomic variables by arguing that most U.S. macroeconomic time series have a unit root (a stochastic trend). For a wide variety of reasons, their research has given rise to several studies examining whether the inflation rate can be thought of as exhibiting a degree of stochastic nonstationarity. For example, using data for industrialized economies, in particular the United States and the United Kingdom, several eminent scholars[see, for example, Baba, Hendry and Starr, 1988; King, Plosser, Stock and Watson, 1991; Johansen, 1992, Ericsson and Irons, 1994; Evans and Lewis, 1995; Crowder and Hoffman, 1996; Ericsson, Hendry and Mizon, 1998; Crowder and Wohar, 1999; Hendry, 2000; Ng and Perron, 2001; Rapach, 2002; Beyer and Farmer, 2002; Rapach and Weber 2004; Lee, 2005; and Russell and Banerjee, 2008]have determined that the inflation rate exhibits a degree of stochastic nonstationarity. As Johansen (1992:313) put it, "Some time series such as the log of prices (P), have the property that even the inflation rate ΔP is nonstationary, whereas the second difference Δ2P is stationary." This characterization of the inflation rate implies that shocks to inflation have a permanent effect because of the presence of a unit root.

Other authors, however, argue that inflation is a stationary variable, and therefore, they suggest that the impact of shocks on such a variable is transitory or dies off over time (see, for example, Rose, 1988; Culver and Papell, 1997; Papelland Prodan, 2004 and Noriega and Ramos-Francia, 2009). The evidence is mixed, and further investigation is necessary.

A common feature of these studies is the use of unit root tests which rely upon a linear framework. The most common practice has been to use the Augmented Dickey-Fuller (ADF) test and similar tests [e.g., the Elliot, Rothenberg and Stock (1996) test] to investigate the existence of nonstationarity in the inflation rate. However, such tests,which are based on linear specifications,have been found not only tohave low power, especially in distinguishing unit root processes from stationary process with large persistence (Froot and Rogoff, 1995), but also to ignore the possibility of nonlinearity.As Kapetanios, Shin and Snell (2003) pointed out, if a variable of interest (e.g., inflation)follows anexponenential smooth-transition autoregressive (ESTAR) process, then the alternative hypothesis of the ADF unit root based on a linear model will be misspecified. Hence, the ADF test will have less power in detecting a unit root hypothesis in the presence of nonlinearities in the data - generating process.

Another feature of the current literature is that little attention has been devoted to less developed countries

(LDCs).There have been two studies: Arize, Malindretos and Nam (2005) and Yoon (2003). The former examines inflation and structural change in fifty developing countries using the fractional integration test of Geweke and Porter-Hudak [1983, GPH hereafter] and concludes that inflation in these countries can be modeled as anonstationary (unit root) variable. Only five African countries (Gabon, Ghana, Kenya, Mauritius and Morocco) are included in that study. Yoon (2003) examines Brazil using the Ng and Perrontechnique and the Elliot, Rothenberg and Stock [1996, hereafter DF-GLS] test and finds that Brazilian inflation contains a unit root.

The purpose of this study is to present new evidence on whether the inflation rate of Africancountries is nonstationary or stationary. This paper has two objectives. The first is to undertake analyses of the data-generation process for the inflation rate in thirty-four African countries over the quarterly period 1980:1 through 2009:3. To our knowledge, this is the first study to comprehensively investigate the time series properties of inflation in Africa, and it includes almost every African country that has enough data for obtaining inflation over the sample period. The results of this study can at least be suggestive of some general conclusions regarding Africa and provide a basis to which future studies can be compared.

Consistent with the preceding discussion, another appealing aspect of our study is that the data are analyzed using both linear and nonlinear unit root tests. The sole reliance on a single test by some previous studies can be misleading and in fact unjustifiable in the presence of alternative tests. Also, it is not necessary to assume a "one-size-fits-all" approach, because a different model may be required to capture the individual nuances of the different countries' data set. Therefore, for the linear unit root tests, we employ two linear unit root tests, namely the DF-GLS test developed by Elliot, Rothenberg and Stock (1996) and the conventional ADF test.Both tests havethe null hypothesis of nonstationarity and the alternative of linear stationarity. In addition, we employ a recently developed ESTAR procedure introduced by Kapetanios, Shin and Snell [hereafter, KSS (2003)], which is of the nonlinear-type and has the null hypothesis of a unit root (or nonstationarity), which is tested against an alternative of nonlinear stationarity. This test has been shown to have a higher power against the conventional ADF tests.

The second objective is to investigate the forecasting ability (stability) of our models to ascertain with some degree of confidence the reliability of our estimates.As stressed by Campbell and Perron (1991), the issue of whether a series has a unit root depends on the purpose a researcher has in mind. Work by Jorion and Sweeney (1996)correctly notes that"from the perspective of either a private investor or of a government exchange-market intervenor, the important issue is forecasting."In a similar vein, Makridakis, Wheelwright and Hyndman (1998: 42) point out that "for the consumer, it is the accuracy of future forecast that is most important." Furthermore, as far as is known, testing the forecasting ability of models in this area is relatively sparse but is practically important. To explore this, we employ three tests, namely the Chow forecast test, the Hendry forecast test and the Dufour forecast test.In sum, the value-added of this study is the use of a wide range of countries in Africa and new testing methodologies. All in all, the study is an advance for LDCs literature on time series properties of inflation.

The structure of the paper is as follows: Section 2 explains briefly why knowledge of the time series properties of inflation is vital. Section 3provides a brief review and outline of the Kapetanios, Shin and Snell(2003) test for nonlinearity. Section 4 examines the empirical results. Section 5 presents the summary and conclusions reached by this study.

2. Why knowledge of the times series properties of inflation rate is vital

Knowledge about the absence or presence of unit roots in inflation is essential to the ability of policymakers to control inflation. This is so because the time series properties of inflation not only are important for choosing which statistical approaches ought to be followed to test a particular hypothesis, but they can also be helpful in distinguishing between different economic hypotheses.

The question of whether the inflation rate is stationary or nonstationary is important in several areas. First, it is fundamental in choosing which statistical techniques are needed for appropriate data analysis. Statistical inference from time series is usually based upon the assumption of stationarity, and Nelson and Plosser (1982), among others, have shown that inferences based on time series that contain a stochastic or unit root feature are less straightforward than in the case of stationary data. This is so because there is the potential for making unreliable and misleading inferences when the variables are nonstationary. For example, it is more meaningful to study a system of inflation rates containing nonstationary variables by employing a cointegration or vector error-correction framework as well as tests for long-run parameter stability and long-run Granger causality. On the other hand, if the variables are nonstationary but not cointegrated, then one may consider a vector autoregression (VAR) in differences. Further, if each variable in the system of inflation rates is stationary, then the system is better approximated by a VAR in levels.

Second, the assumption of nonstationarity in the inflation rate is an important consideration in the estimation of money demand relations. For example, inflation is the sole relevant measure of the opportunity cost of holding money in most developing countries. Virtually all traditional studies of money demand in developing countries have omitted the interest rate variable from the money demand function because changes in these administered interest rates are made infrequently by the government and therefore show little or no variation over time (Arize, 1994).

Third, knowledge of whether or not the inflation rate is nonstationary is also important (given incipient efforts towards financial liberalization in some developing countries) to the empirical estimation of the long-run relationship between the ex ante inflation rate and the nominal interest rates. According to the Fisher hypothesis, the nominal interest rate should move one-for-one with the expected inflation rate. Under the assumption of rational expectations, the deviations of the ex post inflation rate from the ex ante inflation rate are unforecastable, which implies that there is a cointegration relationship between the nominal interest rate and the realized inflation. Some studies, such as Wallace and Warner (1993), found that the inflation rate and the nominal interest rate are both unit root processes that cointegrate in a manner consistent with the Fisher hypothesis. Of course, if both inflation and interest rate are stationary, one cannot employ the cointegration technique.

Finally, whether or not the inflation rate is nonstationary is also important in the empirical investigation of the expectations-augmented Phillips-curve model. Long-run movements in wages and prices are generally thought to be related, and such a view derives from the expectations-augmented Phillips-curve model of the inflation process, where expectations keep shifting the Phillips curve to lower (higher) long-term levels as a result of a contractionary (expansionary) monetary policy. Some studies, such as Mehra (1991), found the presence of two unit roots in both the price and the productivity-adjusted wage rate, so that any shock to inflation has a permanent effect. He also shows that the two variables are cointegrated, which implies that the two variables are related in the Granger causal sense.

There are other theories that assume that the inflation rate is nonstationary. For example, the accelerationist hypothesis implies that monetary authorities have to accept an ever-increasing level of inflation in order to keep unemployment below its natural rate.On the other hand, both the natural rate of inflation hypothesis and the sticky price model of Taylor (1979) assume that inflation is stationarity.

As noted earlier, previous empirical works have been done by using data for industrially developed countries. Little is known about the extent to which their conclusion may be confirmed for developing countries, since these countries have been left out in the discussions. It is well known that the inflation experiences of industrialized countries may differ from those of developing or less developing countries (LDCs). For example, in recent times, industrialized countries have experienced greater reductions in their inflation rate, while, since the 1970s, developing countries have experienced historically high levels of inflation, and in the last few decades most have faced two-digit annual inflation rates caused partially by exogenous events such as the oil crisis.

3. Methodology

In a linear model, the speed of mean reversion is assumed to be uniform or constant at all times. In the case of an ESTAR model, which is of the nonlinear type, the speed of mean or trend reversion to the equilibrium is much stronger when the process is farther away from its mean or trend, whereas when the process is near to the equilibrium it often exhibits unit-root behavior. In that sense, the speed of mean or trend reversion varies with the extent of the deviation from equilibrium.

As is well recognized and discussed robustly in LDCs literature, since the late 1980s, several LDCs emphasized a monetary policy framework that allowed the central bank to employ inflation-targeting strategies. That is, the central bank makes an announcement concerning a quantitative target for inflation, then uses short-term interest rate instrument and moral suasion to ensure that inflation targeting is successful and that inflation is brought within target.

Several LDCs have gone through the transition from being government - controlled economies to semi-market economies. Due to unsatisfactory performance under the former government-control regime, the moves brought significant changes in economic behavior, economic market participants and economic system that could provide nonlinear behavior in the macro-variables such as inflation. This makes it possible to characterize the target variable, in this case the inflation rate, as a two-era process for which the change in eras is smooth rather than sudden. Therefore, the inflation rate may behave as a stationary process in the government-controlled regime (pre-economic liberalization period), but a unit root in the nearmarket-based regime (post-economic liberalization period) (Note 1). This is similar to the argument by Arango and Gonazalez (2001) that some countries such as Colombia have the characteristic of getting to moderate but high levels of inflation quickly, while lower levels, often found in developed economies, are difficult (and much slower) to achieve using reduction-inflation gradual programs.

In line with the preceding discussions, theoretical works by Orphanides and Wieland (2000) and Martin and Miles

(2004) on recent monetary policy analyses have argued that there are central banks which pursue inflation targets and that adjustment to this target is nonlinear. That is, a central bank will at least tend towards output stabilization when inflation is close to its target but will pursue inflation aggressively when inflation is far from its target. In this regard, small deviations from the desired level generally will attract little or no reactions, but large disequilibrium tends to attract aggressive reactions by the central banks. Such nonlinear responses to disequilibrium may, as a result, impart nonlinearity to the dynamics of real variables.

Another theoretical model that can be used to motivate inflation following a nonlinear process is that of Kilian and Manganelli (2007, 2008). The main thrust of their work is the risk management of monetary policy. In their model, the central bank reacts to keep economic growth in line with inflation, depending on where the forecast distribution of inflation lies to prearranged lower and upper limits. Their empirical results suggest that the central bank does not simply respond linearly to the conditional mean of inflation, but rather it allows it to fluctuate within a band of inflation rates, which are never known to the public. In sum, these nonlinear tendencies to disequilibria could inject nonlinearity to inflation rates of African economies; therefore, efforts are made here to determine their correct characterization using also the KSS approach.

3.1. The KSS Test

As noted earlier, the common practice when testing the time series properties of a variable has been to use the ADF and DF-GLS procedures in which the null is nonstationarity and the alternative hypothesis is stationarity. Recently, KSS (2003) expanded the standard ADF test by keeping the null hypothesis as nonstationarity in a time series variable against the alternative of a nonlinear but globally stationarity process. They demonstrate that the new test could be based on the following exponential, smooth transition autoregressive (ESTAR) specification:

$$y_t = y_{t-1} + \gamma y_{t-1}\,[1-\exp(-\theta y_{t-1}^2)] + \varepsilon_t, t = 1, \ldots\ldots, T \quad (1)$$

where ,$\varepsilon_t \sim \mathrm{i.i.d.}(0, \sigma^2)$. Equivalently, the above equation can be rewritten as follows,

$$y_t = \{\,1 + \gamma[1-\exp(-\theta y_{t-1}^2)]\}y_{t-1} + \varepsilon_t \quad (2)$$

Kapetanios, Shin, and Snell (2003) transformed equation (2) as follows,

$$\Delta y_t = \gamma y_{t-1}[1-\exp(-\theta y_{t-1}^2)] + \varepsilon_{t,}\theta \geq 0 \quad (3)$$

whereyt is the de-meaned or detrended series of interest, $\varepsilon_{t,}$ is an i.i.d. error with zero mean and constant variance, and $[1-\exp(-\theta y_{t-1}^2)]$ is the exponential transition function adopted in the test to present the nonlinear adjustment. The null hypothesis of a unit root in $y_t(\mathrm{i.e.}, \Delta y_t = \varepsilon_t)$ implies that$\theta = 0$, so that the term$[1-\exp(-\theta y_{t-1}^2)]$ is 0. If $\theta$is positive, it effectively determines the speed of mean reversion.

The KSS test hence directly focuses on the θ parameter by testing the null hypothesis of nonstationarity H0:$\theta = 0$ against the alternative hypothesis of nonlinear mean-reversion, H1:$\theta > 0$. Because θ in equation (1) is not identified under the null, it is not feasible to directly test the null hypothesis. KSS (2003) thus reparameterize equation (3) by computing a first-order Taylor series approximation to specification (3) to obtain the auxiliary regression specified by equation (4):

$$\Delta y_t = \delta y_{t-1}^3 + \text{error} \quad (4)$$

If the errors in equation (4) are serially correlated, an auxiliary regression with

$$\Delta y_t = \sum_{j-1}^{p} \rho \Delta y_{t-j} + \delta y_{t-1}^3 + \text{error} \quad (5)$$

p augmentations is obtained where the lagged values of the regressand in equation (5) are included to eliminate serially correlated errors from the estimated model. The null hypothesis for equation (4) or (5) is H0:$\delta = 0$, and the alternative hypothesis is H1:$\delta < 0$. The asymptotic critical values to be used in the KSS test are given as the tAKSS statistics in KSS (2003: 364). They show that the conventional t-values for testing nonlinearity have non-standard asymptotic distributions under the unit root, I(1), null; hence, they obtained their critical values through stochastic simulations.

We estimate the tAKSS statistic with equation (5) for the de-meaned data. The de-meaned data are obtained by first regressing each inflation series on a constant and then saving the residuals. Since the standard ADF (DF-GLS) test statistics are also estimated, it is labeled as tADF (tDFGLS) for the model with a constant only. The rejection of the null by the KSS test with the de-meaned data or by the ADF (DF-GLS) test that includes only a constant indicates stationarity of the inflation rate.

Following the suggestion of KSS (2003: 365), the number of augmentation p for the three tests is selected based on the significance testing procedure in Ng and Perron (2001) (Note 2). The maximum number of p was set to eight, mostly because the data are quarterly, and insignificant augmentation terms were excluded (Note 3).

4. Empirical Result

The empirical analysis is based on quarterly data for thirty-four African countries, and the data are drawn from the International Monetary Fund's International Financial Statistics (IFS) CD-ROM (January2010). They cover the sample period from 1980:1 through 2009:3 (i.e., 118 observations). The quarterly data on consumer price indexes are from line 64 of the IFS.

To facilitate our understanding of inflation properties in Africa, we constructed inflation series for each country over the relevant sample period. Inflation rates are constructed by taking the first difference of the natural logarithmic transformation of the CPI indexes and multiplying it by four hundred. Some descriptive statistics for each country are provided in Table 1. The average yearly rate of inflation ranges from 3.75 percent in Mali to 94.78 percent in Angola. The coefficient of variation ranges from 58 percent in South Africa to 626 percent in Rwanda.The Jarque-Bera(JB) statistic points to significant non-normal distributions in thirty-one out of thirty-four countries. The exceptions are Burundi, Mali, and South Africa, where JB statistics are below the critical value of 5.99 at the 5 percent level. Therefore, inflation reveals wide variability and significant deviation from normality during the past two and half decades.

[Table 1 here]

The empirical results for the DF-GLS, ADF and AKSS tests are reported in Table 2 for thirty-four African economies. We report a total of three test statistics in Table 2 for the linear DF-GLS and ADF and nonlinear AKSS tests.

[Tables 2 and 3 here]

Focusing on the first linear test statistics,that is, DF-GLS, the null hypothesis of nonstationarityofinflation is not rejected by the tDFGLS at the 5 percent level of significance in seventeen countries. This suggests that the inflation is nonstationarity in seventeen out of thirty-four cases. These countries are Angola, Cape Verde, Chad, Cote d' Ivoire, Egypt, Gambia, Ghana, Guinea-Bissau, Mauritius, Mozambique, Niger, Nigeria, South Africa, Sudan, Swaziland, Tanzania and Togo.Also, we observe that there are four additional countries in which a fail–to-reject decision is obtained for the null hypothesis of nonstationarity of inflation by tADF but not by tDFGLS. These are Botswana, Kenya, Morocco and Rwanda.

From the nonlinear test results, we observe that there are seven more countries in which a fail-to-reject decision is obtained for the null hypothesis of nonstationarity of inflation rate by tAKSS but not by tDFGLS or tADF. The seven countries are Benin, Burkina Faso, Cameroon, Ethiopia, Gabon, Senegal and Seychelles. In sum, the results from all the linear and nonlinear tests overwhelminglysupport nonstationarity of inflation rate by at least one of the three test statistics in a total of twenty-eight out of thirty-four cases, which is 82.35 percent.

An important issue relates to the performance of each individual test statistic in each country. For example, given our thirty-four countries, the tDFGLS, tADF and tAKSS do not reject the null of nonstationarity in seventeen, thirteen and twenty-five cases, respectively. Other appealing aspects of our results are that (i) the nonlinear unit root test (tAKSS) results provide statistical evidence in support of nonlinear mean-reverting behavior in nine countries (Burundi, Central African Republic, Egypt, Ghana, Guinea-Bissau, Lesotho, Madagascar, Seychelles and Swaziland); and (2) thetAKSS test validatesnonstationarity of inflation in more countries than either the ADF test or the DF-GLS test.

4.1. Forecasting Tests

To provide the reader with some insight into the behavior of inflation over time, we first use the Chow test and treat the break date as known. We chose the breakpoint to keep each subsample roughly the same size. The test was implemented using intercept and slope dummies (see Gujarati, 2003, for details). We focused on the conventional ADF and KSS models. Our results suggest that only the ADF models for Kenya, Seychelles, South Africa, Swaziland and Tanzania are unstable. For the KSS model, only those of Kenya, Mauritius and Seychelles are unstable. We experimented with tests where the break date is unknown. Without discussing each test result in detail, we note that a t-test of the null hypothesis that the mean of the recursive residuals for each of our estimated models (i.e., ADF and KSS) is not statistically significant in all countries, except for Botswana and Seychelles at the 5 percent level. Similar results were obtained from examining the graphs of the cumulative sums (CUSUM) of residuals. Tests suggestedby Nyblom (1989) and Hansen (1992) find instability in the ADF models for Botswana, Central African Republic, Ethiopia, Kenya and Seychelles, but all KSS models were stable except those of

Seychellesand Tanzania.

Focusing now on the forecasting tests, we split our data into estimation and forecast periods. The start of the sample until 2004:3 is treated as the estimation period over which to estimate each ADF or KSS model, whereas the forecast period (out-of-sample period) starts from the sample period 2004:4 through 2009:3.

Table 2 reports the results of three out-of-sample forecast tests for the standard ADF and the nonlinear KSS models. For the ADF model, the Chow test is statistically significant in seven cases, but for the KSS models it is significant in only four cases.From Table 2, we also gather that the Hendry test is statistically significant in five cases for the ADF models, whereas, for the KSS model test, we have six cases. Further, the Dufour test finds only two cases that are statistically significant in the KSS models, whereas for the ADF model, it finds four cases that are statistically significant at the 5 percent level.It seems prudent to check whether these forecasting test results are consistent with those of a traditional measure such as the Theil U statistic. A U value between zero and one $(0 < \mu < 1)$ would suggest that the model yields more accurate prediction than would be a naïve model. For the ADF, the Theil U statistic ranges from a low value of 0.011 for Togo to 0.98 for Gambia. In the case of the AKSS, the statistic ranges from 0.01 in Gambia to 0.99 in Lesotho. Although, the in-sample performance of the AKSS is good, the Theil U statistics indicate that the forecasting performance of the nonlinear model may be inferior to that of the linear ADF model. This finding is consistent with the results in Rapach and Wohar (2006).These results are in the Appendix. Viewed on the basis of these results, our modelshave behaved in a stable mannerdespite experiencing real shocks, such as oil price, drought, civil wars and other forms of political unrest, and terms of trade shocks.

5. Concluding Remarks

This paper examined the time series properties of the African inflation rates by means of linear and nonlinear unit root tests. Thetestshave the null hypothesis of a unit root (nonstationarity), but the alternative hypotheses are different. The alternative hypothesis is linear stationarity for the linear tests, whereas for the nonlinear test, it is nonlinear stationarity. The results show overwhelming support for the nonstationarity of inflation in Africa, implyingthat conventionalcointegration analysis may be appropriate to test money demand models, Fisher effect and expectation-augmented Phillips-curve models.

Several conclusions can now be made. First, we have provided comprehensive evidence for nonstationarity of inflation in Africa that provides additional evidence for the contributions of Arize, Malindretos and Nam (2005) and Yoon (2003) concerning the time series properties of theinflation rate in LDCs. Secondly, conventional linear tests find less evidence of nonstationarity of inflation rate than the nonlinear test of KSS (2003). Had we focused only on the linear tests, we would have obtained more inference bias and missed the nonlinear feature of inflation for these economies. Hence, the present study attributes its findings to the use of both linear and nonlinear tests. Finally, the fact that our parameter and forecast test statistics suggest model stability gives credibility to our findings because only a few countries turned up with significant test statistics. All in all, our results can be used for policy analysis.

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Notes

Note 1. This is an analogue of the case discussed in context of Central and European economies by Cuestas and Harrison (2010).

Note 2. Ng and Perron (2001) demonstrate that the recursive t-statistic (RTS) procedure has better properties (i.e., less size distortions and comparable power) over alternative methods. In brief, RTS method involves: start with a maximum lag, p, lag length chosen a priori and then estimate the ADF model with p lags. If the coefficient on the last included lag is significant at the 10% level (critical value is 1.6), select the lag length equals to p. Otherwise, reduce the order of lags by one until the coefficient on the last included lag is significant.

Note 3. See Stock and Watson (2003: 549-550) for an excellent description of the DF-GLS procedure.

Table 1. Basic characteristics on inflation

Countries	Period	Mean	Standard Deviation	CV	Jarque-Bera
Angola	1996:1-2009:3	94.78	173.42	183	2119.50
Benin	1992:1-2009:3	5.82	14.54	250	3091.79
Botswana	1980:1-2009:3	9.69	4.30	44	34.67
Burkina Faso	1980:1-2009:3	3.83	10.78	282	113.91
Burundi	1980:1-2009:3	10.32	14.05	136	1.84
Cameroon	1980:1-2009:3	5.43	10.81	199	1039.18
Cape Verde	1984:1-2009:3	4.54	9.39	207	12.90
Central African Republic	1980:1-2009:3	4.03	22.32	554	7142.40
Chad	1983:2-2009:3	4.75	25.57	538	58.61
Cote D' Ivoire	1980:1-2009:3	5.00	8.96	179	826.62
Egypt	1980:1-2009:3	11.11	10.22	92	26.39
Ethiopia	1980:1-2009:3	7.59	18.13	239	121.13
Gabon	1980:1-2009:3	3.60	12.64	351	614.64
Gambia	1980:1-2009:3	9.57	12.69	133	236.57
Ghana	1980:1-2009:3	27.63	32.39	117	1222.33
Guinea-Bissau	1986:2-2009:3	24.42	37.73	154	75.12
Kenya	1980:1-2009:3	12.91	13.89	108	84.51
Lesotho	1980:1-2009:3	9.16	15.74	172	4006.75
Madagascar	1980:1-2009:3	14.44	16.51	114	67.14
Malawi	1980:1-2009:3	19.12	26.41	138	31.30
Mali	1987:3-2009:3	3.42	12.37	362	4.62
Mauritius	1980:1-2009:3	7.02	5.82	83	83.33
Morocco	1980:1-2009:3	4.41	5.22	118	27.64
Mozambique	1992:3-2009:3	17.30	21.47	124	43.62
Niger	1980:1-2009:3	3.75	18.15	484	135.20
Nigeria	1980:1-2009:3	19.56	22.72	116	28.04
Rwanda	1980:1-2009:3	15.55	97.27	626	10493.07
Senegal	1980:1-2009:3	4.21	12.05	286	736.45
Seychelles	1980:1-2009:3	4.92	15.68	318	1028.22
South Africa	1980:1-2009:3	9.50	5.52	58	0.61
Sudan	1980:1-2009:3	37.70	60.51	161	685.21
Swaziland	1980:1-2009:3	10.52	10.26	98	370.03
Tanzania	1980:1-2009:3	18.49	21.28	115	41.74
Togo	1980:1-2009:3	5.64	31.09	551	8097.70

Notes: CV is the coefficient of variation and the Jarque-Bera statistic is distributed as Chi-square with 2 degrees of freedom. The critical value is 5.99.

Table 2. Unit Root Linear Tests of Inflation for African countries

		Linear Tests						
		H :non-stationarity; H_a:stationarity						
				Forecasting Tests				
Country	**Period**	t_{DFGLS}	t_{ADF}	***Chow Test***	***Hendry Test***	***Dufour Test*** ***Test***		***p-value***
Angola	1996:1-2009:3	-0.28	-1.24	0.10	8.40	F(20,17)	0.04	(1.00)
Benin	1992:1-2009:3	-3.03*	-3.55*	0.14	2.88	F(20,43)	0.14	(1.00)
Botswana	1980:1-2009:3	-2.43*	-2.42	1.59*	51.54*	F(20,81)	1.55	(0.09)
Burkina Faso	1980:1-2009:3	-7.54*	-7.76*	0.46	9.58	F(20,93)	0.46	(0.97)
Burundi	1980:1-2009:3	-5.61*	-6.16*	0.89	17.33	F(20,93)	0.89	(0.60)
Cameroon	1980:1-2009:3	-5.38*	-5.47*	0.15	2.98	F(20,93)	0.15	(1.00)
Cape Verde	1984:1-2009:3	-0.57	-2.60	0.35	7.97	F(20,65)	0.35	(0.99)
Central African Republic	1980:1-2009:3	-6.58*	-6.86*	19.45*	454.73*	F(20,93)	19.45*	(0.00)
Chad	1983:2-2009:3	-1.60	-5.20*	0.53	10.65	F(20,72)	0.09	(1.00)
Cote D' Ivoire	1980:1-2009:3	-0.24	-4.17*	0.43	9.14	F(20,87)	0.43	(0.98)
Egypt	1980:1-2009:3	-0.82	-1.42	0.59	13.24	F(20,81)	0.59	(0.91)
Ethiopia	1980:1-2009:3	-4.90*	-4.65*	2.08*	66.55*	F(20,87)	2.08*	(0.01)
Gabon	1980:1-2009:3	-2.55*	-4.39*	0.15	4.82	F(20,81)	0.15	(1.00)
Gambia	1980:1-2009:3	-1.88	-4.41*	0.23	4.55	F(20,93)	0.23	(1.00)
Ghana	1980:1-2009:3	-0.30	-2.20	0.08	1.78	F(20,81)	0.08	(1.00)
Guinea-Bissau	1986:2-2009:3	-0.28	-1.78	0.09	18.82	F(20,58)	0.09	(1.00)
Kenya	1980:1-2009:3	-2.61*	-2.66	2.94*	4.52	F(20,81)	2.33*	(0.00)
Lesotho	1980:1-2009:3	-6.85*	-6.83*	0.06	1.14	F(20,93)	0.06	(1.00)
Madagascar	1980:1-2009:3	-2.67*	-2.99*	0.24	7.18	F(20,81)	0.24	(1.00)
Malawi	1980:1-2009:3	-2.96*	-4.08*	0.23	14.80	F(20,85)	0.23	(1.00)
Mali	1987:3-2009:3	-2.52*	-3.02*	0.78	15.10	F(20,53)	0.78	(0.73)
Mauritius	1980:1-2009:3	-1.65	-4.51*	1.11	18.66	F(20,83)	1.11	(0.36)
Morocco	1980:1-2009:3	-3.10*	-2.85	0.37	12.39	F(20,81)	0.37	(0.99)
Mozambique	1992:3-2009:3	-0.80	-2.86*	0.54	0.01	F(20,29)	0.54	(0.92)
Niger	1980:1-2009:3	-0.92	-5.54*	0.34	7.33	F(20,85)	0.34	(1.00)
Nigeria	1980:1-2009:3	-1.82	-3.00*	0.76	15.84	F(20,79)	0.78	(0.73)
Rwanda	1980:1-2009:3	-2.74*	-2.53	0.80	16.10	F(20,79)	0.80	(0.70)
Senegal	1980:1-2009:3	-3.57*	-3.65*	0.21	5.64	F(20,89)	0.21	(1.00)
Seychelles	1980:1-2009:3	-2.73*	-3.06*	3.81*	95.82*	F(20,83)	3.59*	(0.00)
South Africa	1980:1-2009:3	-1.32	-1.79	0.51	11.34	F(20,83)	0.51	(0.96)
Sudan	1980:1-2009:3	-1.13	-0.78	3.72*	71.51*	F(20,79)	0.13	(1.00)
Swaziland	1980:1-2009:3	-0.97	-2.70	0.29	5.51	F(20,79)	0.29	(1.00)
Tanzania	1980:1-2009:3	-0.29	-0.79	0.12	6.82	F(20,79)	0.12	(1.00)
Togo	1980:1-2009:3	-1.61	-5.16*	0.04	1.54	F(20,87)	0.04	(1.00)
Critical Values at 5%:		-1.95	-2.86		31.41			
Note. For DFGLS, ADF and AKSS, an * denotes rejection the null of non-stationarity at the 5% significance level. An * implies that the inflation is stationarity. F* is the F-test.								

Table 3. Unit Root Non-Linear Test of Inflation for African countries

		Non-Linear Tests					
		H :non-stationarity; H_a:stationarity					
			Forecasting Tests				
Country	**Period**	t_{AKSS}	***Chow Test***	***Hendry Test***	***Dufour Test***	***F****	***p-value***
Angola	1996:1-2009:3	-1.78	0.06	3.58	F (20,18)	0.06	(1.00)
Benin	1992:1-2009:3	-1.07	0.66	19.54	F (20,34)	0.66	(0.33)
Botswana	1980:1-2009:3	-1.13	1.86	63.57*	F (20,82)	1.71*	(0.05)
Burkina Faso	1980:1-2009:3	-0.65	0.48	14.91	F (20,82)	0.48	(0.97)
Burundi	1980:1-2009:3	-4.12*	0.79	19.04	F (20,92)	0.79	(0.72)
Cameroon	1980:1-2009:3	-1.04	0.13	3.74	F (20,80)	0.13	(1.00)
Cape Verde	1984:1-2009:3	-1.43	0.37	7.57	F (20,66)	0.37	(0.99)
Central African Republic	1980:1-2009:3	-2.99*	15.36*	399.60*	F (20,86)	1.36	(0.99)
Chad	1983:2-2009:3	-2.26	0.60	18.26	F (20,69)	0.59	(0.91)
Cote D' Ivoire	1980:1-2009:3	-0.55	0.42	0.11	F (20,82)	0.37	(0.99)
Egypt	1980:1-2009:3	-3.54*	0.57	14.35	F (20,82)	0.57	(0.92)
Ethiopia	1980:1-2009:3	-2.45	1.33	43.33*	F (20,82)	1.33	(0.19)
Gabon	1980:1-2009:3	-0.26	0.14	4.31	F (20,90)	0.14	(1.00)
Gambia	1980:1-2009:3	-0.77	0.23	4.73	F (20,84)	0.23	(1.00)
Ghana	1980:1-2009:3	-6.86*	0.11	4.09	F (20,82)	0.11	(1.00)
Guinea-Bissau	1986:2-2009:3	-4.00*	0.10	3.11	F (20,59)	0.10	(1.00)
Kenya	1980:1-2009:3	-0.24	3.04*	111.66*	F (20,82)	2.23*	(0.01)
Lesotho	1980:1-2009:3	-5.97*	0.04	0.84	F (20,94)	0.04	(1.00)
Madagascar	1980:1-2009:3	-3.02*	0.28	2.50	F (20,82)	0.28	(1.00)
Malawi	1980:1-2009:3	-0.05	0.10	15.71	F (20,82)	0.10	(1.00)
Mali	1987:3-2009:3	-0.02	0.87	22.54	F (20,54)	0.87	(0.62)
Mauritius	1980:1-2009:3	-1.34	1.25	29.02	F (20,82)	1.25	(0.24)
Morocco	1980:1-2009:3	-1.94	0.38	16.72	F (20,82)	0.38	(0.99)
Mozambique	1992:3-2009:3	-2.40	0.61	14.01	F (20,30)	0.61	(0.87)
Niger	1980:1-2009:3	-1.75	0.44	7.04	F (20,82)	0.44	(0.98)
Nigeria	1980:1-2009:3	-1.66	0.84	23.90	F (20,82)	0.84	(0.66)
Rwanda	1980:1-2009:3	-0.42	0.74	14.42	F (20,80)	0.74	(0.77)
Senegal	1980:1-2009:3	-0.14	0.19	6.74	F (20,82)	0.18	(1.00)
Seychelles	1980:1-2009:3	-3.22*	2.98*	63.46*	F (20,90)	2.40*	(0.00)
South Africa	1980:1-2009:3	-1.08	0.53	11.64	F (20,84)	0.53	(0.94)
Sudan	1980:1-2009:3	-0.57	0.12	4.41	F (20,80)	0.12	(1.00)
Swaziland	1980:1-2009:3	-4.17*	0.23	4.85	F (20,80)	0.23	(1.00)
Tanzania	1980:1-2009:3	-1.16	2.63*	47.08*	F (20,80)	0.12	(1.00)
Togo	1980:1-2009:3	-0.99	0.06	1.19	F (20,82)	0.06	(1.00)
Critical Values at 5%:		-2.93		31.41			

Appendix*:*

TheilU Statistics

Countries	ADF	AKSS
Angola	0.27	0.23
Benin	0.33	0.95
Botswana	0.6	0.75
Burkina Faso	0.44	0.75
Burundi	0.5	0.71
Cameroon	0.58	0.94
Cape Verde	0.53	0.75
Central African Republic	0.56	0.48
Chad	0.22	0.75
Cote D' Ivoire	0.49	0.66
Egypt	0.82	0.89
Ethiopia	0.51	0.75
Gabon	0.45	0.96
Gambia	0.98	0.01
Ghana	0.29	0.44
Guinea-Bissau	0.58	0.78
Kenya	0.61	0.9
Lesotho	0.55	0.99
Madagascar	0.55	0.86
Malawi	0.25	0.34
Mali	0.3	0.73
Mauritius	0.46	0.84
Morocco	0.5	0.68
Mozambique	0.46	0.68
Niger	0.36	0.71
Nigeria	0.61	0.85
Rwanda	0.94	0.97
Senegal	0.5	0.78
Seychelles	0.34	0.68
South Africa	0.71	0.75
Sudan	0.74	0.46
Swaziland	0.38	0.01
Tanzania	0.63	0.66
Togo	0.01	0.86

Note: A Theil$U$ value equal to one would suggest that the model forecasts are as good as naïve. While, a U statistic greater (less) than one shows that the no change forecast is better (worse) than the forecasts from the naive model.